Examination of Health Effects and Long-Term Impacts of Deployments of Multiple Tag Types on Blue, Humpback, and Gray Whales in the Eastern North Pacific

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LONG-TERM GOALS

The goal of this project is to provide new insights into the long term consequences of different types of tags on several additional species of large whales including blue, humpback, and gray whales by conducting long term follow up of previously tagged individuals in the eastern North Pacific. We examine the long term impacts on health, reproduction, and mortality unitizing the past deployments of implant and suction cup tags on blue, humpback, and gray whales in the eastern North Pacific and our extensive monitoring of these populations. Despite extensive use of implant tags for more than 30 years (Mate et al. 2007), only limited studies have been conducted of the health effects and long-term consequences of tag deployments on whales. This field is rapidly expanding including increased use of deep penetration tags on many populations including critically endangered populations such as the North Pacific right whale and the western gray whale. Studies of North Atlantic rights whales revealed a wide variety of conditions of the tag site after deployments of penetration tags varying from very minor divots to more extensive swellings.

OBJECTIVES

The overall objectives for this multi-year project are as follows:

1. Examine the long-term survival of tagged animals in relation to animals that were not tagged.
2. Test for differences in the visual health status of tagged versus untagged animals.
3. Examine the condition of the tag site and evaluate healing in tagged animals.

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APPROACH

Long term impacts of tagging are being examined by conducting detailed follow-up of blue, humpback, and gray whales that have had tags deployed on them to examine site healing, health, and any long-term consequences of tag deployment on reproduction, health, or survival. Our focus on three species of baleen whales in the Eastern North Pacific represents an ideal test case to study this for two primary reasons:

1. Some of the longest histories of tag deployments have been conducted in this area on these species. This includes over 400 deployments of a wide variety of tags ranging from suction-cup, external tags anchored into blubber, and full implant tags on blue whales (Mate et al. 2007, Calambokidis et al. 2008). This sample includes the largest number of implant tag deployments of any whale population (OSU implant tag deployments on approximately 183 eastern North Pacific blue whales, for example).
2. Extensive sighting histories of blue, humpback, and seasonal-resident gray whales are available off the US West Coast from photo-identification studies; these studies have been virtually uninterrupted since 1986 with continued monitoring planned (Calambokidis et al 2002, 2010, Calambokidis and Barlow 2004). In all three species, the majority of the population has been photo-identified and resighting rates are very high. Seasonal resident gray whales in this region have annual resighting rates of 70% or more and catalogs of identified blue and humpback number over 2,000 individuals each.

We used both photographs and genetics to conduct the first systematic reconciliation of the animals tagged with the long-term photo-ID datasets. Photographs and video taken from deployments were used to catalog both the photo-ID identities and the markings immediately around the tag site of whales to add to those where a match between tagged animal and photo-ID has already been made and those gathered of during the study. Additional determinations of identity is being made based on genetic matches between samples taken from about 100 implant-tagged whales and those collected from animals in these populations.

WORK COMPLETED

The following major areas of work were conducted in 2013:

1. We have collaborated with OSU and obtained identification photographs of blue, gray, and humpback whales that have been previously tagged by OSU and matched these to our catalogs. Genetic samples of tagged animals have also been used to look for genetic matches of animals.
2. We have compiled identifications and sightings of follow up photographs and sightings of eastern North Pacific gray whales tagged in 2009 as well as new deployments done in 2012.
3. We have continued additional field work including work in collaboration with other studies obtaining photographs of blue whales including for photographic identification, for examination of potential tag sites, and for visual health assessment of blue whales.
4. Developed a system for categorizing tag injuries working with our veterinary pathology team

5. Compiled follow up photographs of the tag site of gray and blue whales and completed an initial round of condition scoring for these.
6. Collaborated with CICIMAR on a comparison of their catalog of blue whales in Mexico with ours to extend the sighting histories of tagged animals and add to the time series photographs. This included collaborating on a potential publication documenting the follow up observations of a blue whale with large swelling after satellite tagging.
7. Collaborated with Jeff Jacobsen to examine if there are additional humpback whales from satellite tagging operations on Socorro that can be linked to photographic identifications to allow long term assessment of tag site condition and resighting.
8. Organized a workshop for 8 December 2013 in Dunedin ahead of the Biennial Conference on the Biology of Marine Mammals specifically on follow up studies on the impacts of tagging. Workshop quickly filled to capacity.
9. Continued obtaining detailed photographs of blue, humpback, and gray whales off the US West Coast to provide information on survival, allow better assessment of health, and also a detailed view of parts of the body where tags may have been applied. Typically in the past, only the portion of blue whales used in photographic identification were obtained so these recent photographs will provide a better basis of assessment of health and tag condition than had been available.

RESULTS

Summarized below are the results of different components of the research completed to date. These reflect updated results obtained during 2013 including the identification of additional animals from more detailed examination of photos taken during tagging as well as using more photos obtained through the 2012 field season which helped identify animals. We have also increased the years of resighting data available to include 2012 field effort and also to further score follow up wound healing. Results of genetic analyses conducted of whales satellite tagged by OSU have been completed and were summarized in the previous annual report. Some of the preliminary results of determining the photo-ID of blue, humpback, and gray whales that had been tagged to be able to conduct follow up examinations are summarized below (Table 1).

Table 1. Summary of photo-ID and resightings of different species of whales tagged with suction cup or implant tags.

Species	***Attach Type***	***Total Tags Deployed***	***Deploy-ments whale photo-IDed***	***Unique identified whales Tagged***	***Resighted a later season Post Tagging***	***Percent Resighted***
Blue whale	*Cup*	*270*	*201*	*120*	*77*	*64%*
Blue whale	*Satellite tag total*	*183*	*79*	*79*	*61*	*77%*
	External	*53*	*18*	*18*	*14*	*78%*
	Internal	*129*	*61*	*61*	*47*	*77%*
Gray whale PCFG -2009	*Implant*	*18*	*18*	*18*	*16*	*89%*

Gray whale MX	*Implant*	*17*	*6*	*6*	*0*	*0%*
Humpback	*Cup*	*20*	*12*	*10*	*10*	*100%*
Humpback	*Implant*	*33*	*4*	*4*	*3*	*75%*

Our largest sample of identified whales comes from the large number of blue whales that have been tagged with either implant tags or suction cup tags (Table 1). Of the 270 suction cup tags deployed on blue whales through 2011, good identification photographs were available for 201 cases and these represented 120 different individuals (some whales were tagged more than once). We were able to close to double the number of implant tagged blue whales that were photo-identified from what was previously available and now have 79 of 183 implant tagged whales identified. Our resighting rates for tagged blue whales is currently slightly higher for implant tagged blue whales than suction cup tagged whales due to most of the suction cup tagging having occurred in recent years from work on ship strike and the SOCAL BRS (Southall et al. 2012, Goldbogen et al. 2013, Calambokidis et al. 2013) so there have not been many opportunities to resight these animals since they were tagged. The large sample now available of blue whales that had suction-cup tags applied (see for example Oleson et al. 2007, Calambokidis et al. 2008, Goldbogen et al. 2013) will be useful both as a comparison to implant tags but also to assess impacts of these tags as well. While suction-cup tags have been considered lower impact than implant tags, some preliminary results indicate that in some cases these types of tags can cause injuries that penetrate the skin.

Of 18 gray whales OSU satellite tagged in the Pacific Northwest in fall 2009, all 18 were photo-identified either with photographs taken at the time or later and all were known animals present in Cascadia's catalog of eastern North Pacific gray whales. (Table 2). Cascadia maintains a catalog of eastern North Pacific gray whales that consists of about 1,000 individuals identified off California, Oregon, Washington, and British Columbia by Cascadia and other collaborators under a project primarily sponsored by the National Marine Mammal Laboratory (Calambokidis et al. 2002, 2010). The core of this catalog is the estimated 200-250 gray whales that regularly use the Pacific Northwest for feeding each spring, summer, and fall. In addition to photo-ID, recent genetics studies have revealed significant differences in mtDNA between these animals and other eastern North Pacific gray whales suggesting these should be treated as an independent demographic unit (Frasier et al. 2011, Lang et al. In Press).

Resightings of the tagged PCFG whales through 2012 is summarized in Table 2 and compared to a control groups of animals in Table 3. Overall, 16 of the 18 PCFG gray whales tagged in 2009 have been resighted in a subsequent year (2010-12). Highlighted in the table and 4 whales where they may have been a problem, three that have not been seen Jan 2010 at the latest and one known to have died at the end of 2011 (CRC 411). The identity of the whale that died as one of those that had been tagged was not realized until well after the stranding and unfortunately no examination was conducted to allow determination of any possible connection of the death to the tagging that had occurred more than two years earlier. While 4 of the 18 tagged whales had not been resighted or were known to have died, the same was only true for 1 of 45 animals identified as controls (Table 3) which were selected due to their having been identified in the same region and time period as the tagged animals (but not tagged) and like the tagged animals were known individuals from the PCFG.

Table 2. Identification histories of PCFG gray whales that were tagged by OSU in fall 2009. Numbers underneath years indicate the number of times the whale was sighted that year. Red highlight indicates two whales not sighted in a subsequent year post-tagging, another whale that has not been seen since Jan 2010 and a 4th whale known to have die (in 2011).

ID	TAG Number	Tagged	1985	1991	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Comments
32	PTT 5205938	2009	1			1			2	16			18	3	6			2		**4**				
89	PTT 5223029	2009			2				20	21	30	13	4	23	10	19	16	8	16	**19**	20	24	30	
164	PTT 5210836	2009		1		7					3	1	1			1	1		1	**9**	14	9	2	
196	PTT 5210838	2009,12					1				2		1	9		6	14	6	8	**21**	24	14*	**12**	*w/ calf
205	PTT 5210842	2009					2	9		6	1	3	3	5					7	**19**	5	6		
206	PTT 5205923	2009					4		3	2	1	3	4	3				2		**9**	1	3		
215	PTT 5205670	2009					2		1				5	4	1			3		**15**	2			Last Jan 2010
291	PTT 5223032	2009							2	2	1	3	6	10	4	1	5		1	**10**	3	16	3	
302	PTT 5205801	2009							4	8	1		4	14	10	1	15	6	15	**8**	16	14	13	
411	PTT 5223038	2009								1	4	8	4					2	3	**11**	7	11		Dead 2011
525	PTT 5200847	2009									1	2	1		1	2	1	4	23	**16**	4		1	
537	PTT 5200831	2009									2			1				1	1	**14**	12	5	1	
615	PTT 5223033	2009										1	1						2	**3**	5	4	1	
643	PTT 5204174	2009										1	2	1		2			3	**13**	1	9	1	
659	PTT 5200827	2009											2		5		1		1	**19**	7	5	7	
797	PTT 5223035	2009												1	2	7	18	12	13	**7**				
854	PTT 5201385	2009														1			3	**11**	8	9	1	
981	PTT 5223041	2009																1		**10**	7	8	4	

Table 3. Sighting histories of whales selected as potential controls for the 2009 tagged whales (identified in the same region and time period as the tagged whales and previously identified). Similar to Table 2, highlighted record is for a whale not seen since January 2010.

ID	1984	1986	1988	1990	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
6		1										1		5	3		1		1	1	1	**4**	2	3	5
42	3		1	1		5	2	2	2		24	26	9	13	24	7	5	2	15	2	19	**10**			13
87						2			2		24	12	36	18	10	8	5	3	10	1	13	**7**	7	18	26
93	2					1			2	1	10	9	18	13	8	4	6		2		11	**5**		5	20
107							2	1		2	7	1	34	10	1	15	11	9	10	3	13	**8**	25	29	24
123										3	8	6	9	8	22	10	8	7	21	1	2	**17**	7	30	26
127		1								4	1	3	26	19	1	14		9		4		**1**	20	13	2
141				1		1		2		2	16	5		7	8	3	13	4	1	6	5	**3**	4	1	5
166								4	4	10	18	18	44	44	18	30	26	12	22		12	**18**	4	2	
169								4						3	5	10	5	3	7	2	5	**4**	1	2	9
204									1	1	1	2	45	3	5	14		10	3	4	3	**8**	11	16	6
231											30	31			6	1	2	3	3	1	3	**4**	3	1	4
277											4		1									**5**		9	3
278											1			2	2	2		1				**2**	6	9	7
280											3				3	1			3	2		**10**	1	19	1
285					1									2	1							**2**	3	5	4
289					1						1		1	4	1					1		**6**	4	13	
293											1			2	4	3	1			2		**1**		2	
295					1						7			1	1	2	2	6	1	2	6	**3**	8	13	4
297											2	2		4	1	1		1	2		1	**4**	1	1	2
300											22	5	40			3			11	4	10	**7**	3		
311											10	2	4	3	3	11	1		2	1	4	**8**	8	14	5
319											2		2	13	2	1	1		3		20	**4**	1	4	4
330										5	2				15		1					**2**			4
364												1	2		3			1		6		**8**	11	11	8
365												1	1	3	4	3					1	**2**	5	17	6
464												1	2		6						1	**1**	3	7	7
510													2	1	11	6	1		2	1	7	**3**	22	14	15
551													1		2							**3**	5	4	
554											3		3	2	2	2	6		1	1	10	**11**	15	22	
555													6		4	3			1		1	**9**	15	28	2
565													1		2					8		**9**	7	12	14
583														5	1	6		6	2	12	13	**27**	4	18	3
611														4						1		**4**	3	9	4
639														1	2					1		**4**		5	
657															2	1		1	1	3	2	**7**	4	3	6
669															6	4	2			2	2	**8**	18	6	
696															3	16	11	14	15		21	**19**	24	41	28
698															4	8	1	12	9	1	11	**3**	2	65	12
703															2		1			1		**5**		6	
714															1				6	1	16	**7**	2	31	28
759											3				16	9	17		2	2	26	**3**	1		1
780																					4	**11**	11	23	2
791																7	3	3				**2**	4	20	13
840																		3			1	**10**	1	11	4

Results of evaluation of the condition of the tag site has been conducted for satellite tagged blue and gray whales (Table 4). These reflect the objective scoring conducted independently by two researchers (Stephanie Norman and Kiirsten Flynn). These show the prevalence of a couple of the more common tag site conditions (swelling and depression). Example of one of the two cases with the most extreme and prolonged swelling appear in Figure 1. These two blue whales (CRC ID 1573 and 2208) had both been tagged in 1995 by OSU with early versions where tag was external but was anchored with two long barbs (Mate et al. 2007). We suspect that these more extreme prolonged swellings were the result of one of these barbs breaking off and staying in the animal for an extended period. One of these two whales was extensively encountered by CICIMAR in the Gulf of California, Mexico and serves as a case study describing the long term sighting history of this individual (Gendron et al. In prep.).

Table 4. Physical scoring of post-tagging resight photographs of 17 resighted gray whales satellite tagged in 2009 and 71 resighted blue whales that were satellite tagged going back to the 1990s. Results are part of scores based on 21 objective questions an d scored by two researchers.

Species	Tagged	Resighted	Depression	Swelling	Either	Both
Gray whale-2009	18	17	17(100%)	15(88%)	17 (100%)	14(82%)
Blue whale	183	71	34(48%)	19(27%)	40(56%)	13(18%)

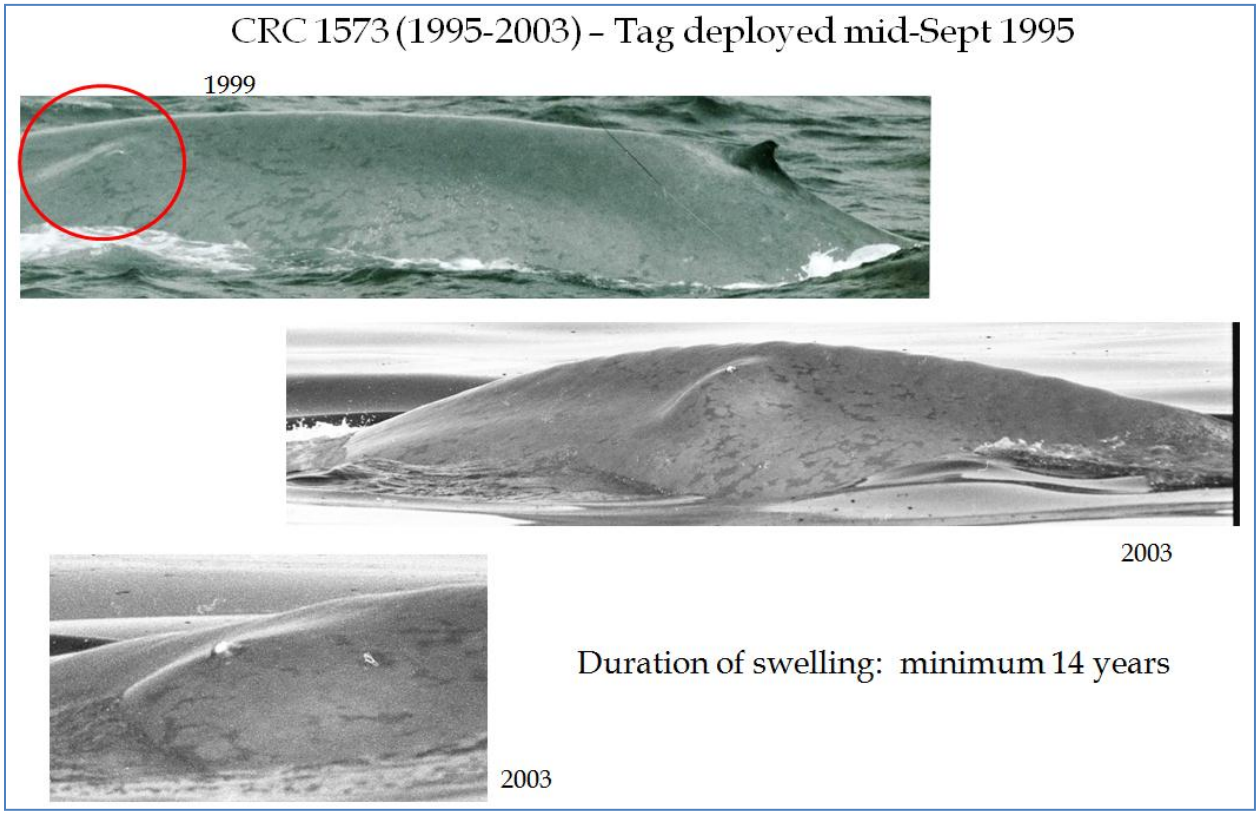

Figure 1. Example of sever swelling a post-tag blue whale (CRC ID 1573) that represents one of two blue whales that showed the most extreme and prolonged swelling.

RELATED PROJECTS

None of the animals tagged and the subject of this study were actually tagged as part of this research project and are from previous or current project funded separately, many of them with support from ONR. Analysis of the follow up satellite tagged PCFG gray whales conducted under this project has also been undertaken by OSU more focused on some of the more short term portions of the follow up and Cascadia more focused on longer term follow up.

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Bruce Mate and Craig Hayslip at OSU assisted in identifying the satellite tagged whales. Scott Baker and Debbie Steele conducted genetic identifications. Stephanie Norman conducted helped generate the tag site scoring system and conducting evaluation of photographs. Our Veterinary pathology team included Stephanie Norman, Stephen Raverty, Francis Gulland, Michael Moore, and David Rotstein. Annie Douglas worked with OSU on initial identification of the tagged blue whales. Alie Perez conducted the identifications of the tagged gray whales. Kiirsten Flynn conducted the photo selection, scoring, and data compilation. Collaborators including CICMAR (Diane Gendron), MICS (Richard Sears and Christian Ramp), Michael Fishback, Jeff Jacobsen, Dawn Goley, and others assisted in providing important photographs and data for assessment of tagged animals.

REFERENCES

Calambokidis, J. and J. Barlow. 2004. Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. *Marine Mammal Science* 20(1):63-85.

Calambokidis, J and J. Barlow. 2013. Trends in humpback and blue whales off the US West Coast and their relationship to ship strike mortality. Abstract (Proceedings) 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, NZ, December 2013.

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, and B. Gisborne. 2002. Abundance, range and movements of a feeding aggregation of gray whales *(Eschrichtius robustus*) from California to southeastern Alaska in 1998. *Journal of Cetacean Research and Management* 4(3):267-276.

Calambokidis, J., J.L. Laake, A. Klimek. 2010. Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998-2008. Report SC/62/BRG32 submitted to IWC Scientific Committee, June 2010. 50 pp.

Frasier, T., Koroscil, S., White, B., and Darling, J. (2011). Assessment of population structure in relation to summer feeding ground use in the eastern North Pacific gray whale. *Endangered Species Research* 14:39-48.

Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society B.* 280: 20130657. http://dx.doi.org/10.1098/rspb.2013.0657

Lang, A.R., J. Calambokidis, J. Scordino, V.L. Pease, A. Klimek, V.N. Burkanov, P. Gearin, D.I. Litovka, K.M. Robertson, B.R. Mate, J.K. Jacobsen, and B.L. Taylor. In Press. Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. *Marine Mammal Science*

Mate, B.R., B. Lagerquist and L. Irvine. 2010. Feeding habitats, migrations and winter reproductive range movements derived from satellite-monitored radio tags on eastern North Pacific gray whales. Document submitted to the IWC Scientific Committee. 22 pp. Agadir, Morocco, 30 May - 11 June 2010. (SC/62/BRG21)

Mate, B., R. Mesecar R, and B.A. Lagerquist. 2007. The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. *Deep Sea Research II* 54:224-247

Oleson, E.M., J. Calambokidis, W.C. Burgess, M.A. McDonald, C.A. LeDuc, and J.A. Hildebrand. 2007. Behavioral context of call production by eastern North Pacific blue whales. *Marine Ecology Progress Series* 330:269-284.

Southall, B.L., D. Moretti, B. Abraham, J. Calambokidis, S.L. DeRuiter, and P.L. Tyack. 2012. Marine Mammal Behavioral Response Studies in Southern California: Advances in Technology and Experimental Methods. *Marine Technology Society Journal* 46(4): 46-59.